Electron Cloud Effect and Two-Stream Instability in Electron-Ion Colliders

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Two-stream instability

- Beam interaction with elements of accelerator and secondary plasma can be the reason for instabilities, causing limited beam performance.
- Improving of vacuum chamber design and reducing of impedance by orders of magnitude relative with earlier accelerators increases threshold intensity for impedance instability.
- Two-stream effects (beam interaction with a secondary plasma) become a new limitation on the beam intensity and brightness. Electron and Antiproton beams are perturbed by accumulated positive ions. Proton and positron beams may be affected by electrons or negative ions generated by the beam. These secondary particles can induce very fast and strong instabilities. These instabilities become more severe in accelerators and storage rings operating with high current and small bunch spacing

E cloud and e-p two-stream instability.

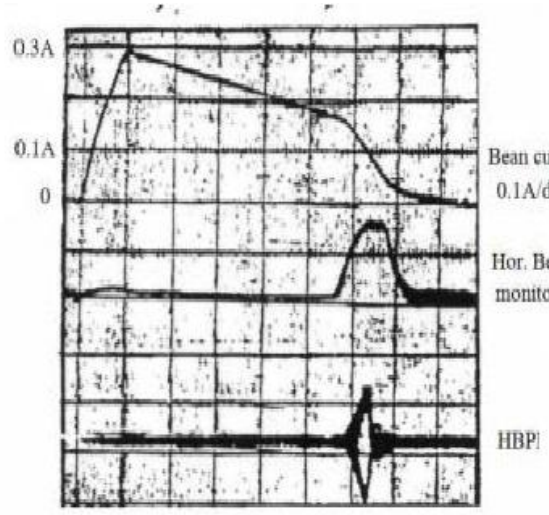
Courtesy L.Wang

Overview

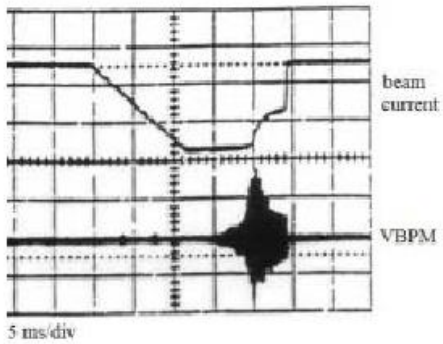
- 1965 INP PSR transverse instability & beam loss
- 1971 ISR e-p, 1977 beam-induced multipacting
- 1988 LANL PSR vertical instability & beam loss
- 1989 KEK PF vertical coupled bunch instability(CBI)
- since 1996 BEPC IHEP-KEK collaboration(CBI)
- 1997 LHC crash program launched at CERN
- 1997 CESR trapped ecloud causes coupled bunch instability
- 1997/98 APS e-cloud studies start
- since 1998 SPS e. cloud with LHC beam
- 2000 PS e-cloud with LHC beam (Heating & instability)
- Since 1999 e-cloud at KEKB and PEP-II (blow-up, pressure rise, tune shift along the train, CBI, luminosity drop…)
- Since October 2001 evidence for e-cloud at RHIC (Vacuum pressure…)
- Observation of secondary particles in the booster proton beam are presented in the Booster E-Log at 04/06/01, Tevatron…

E cloud and e-p two-stream instability.

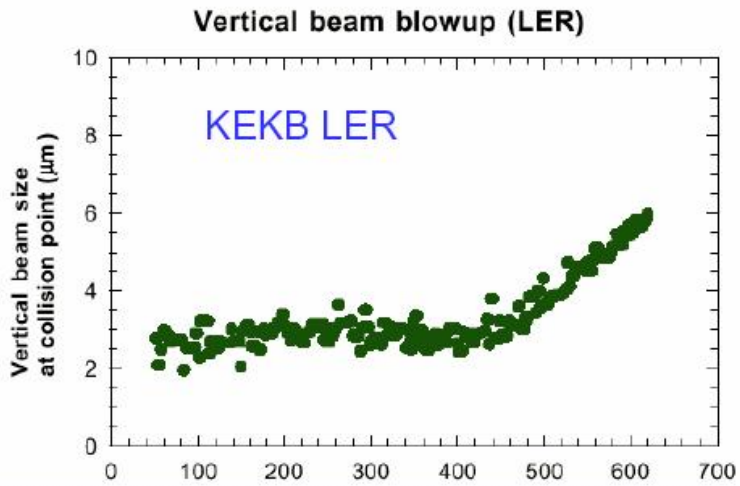
Courtesy L.Wang



Transverse instability in the INP PSR bunched beam (1965)

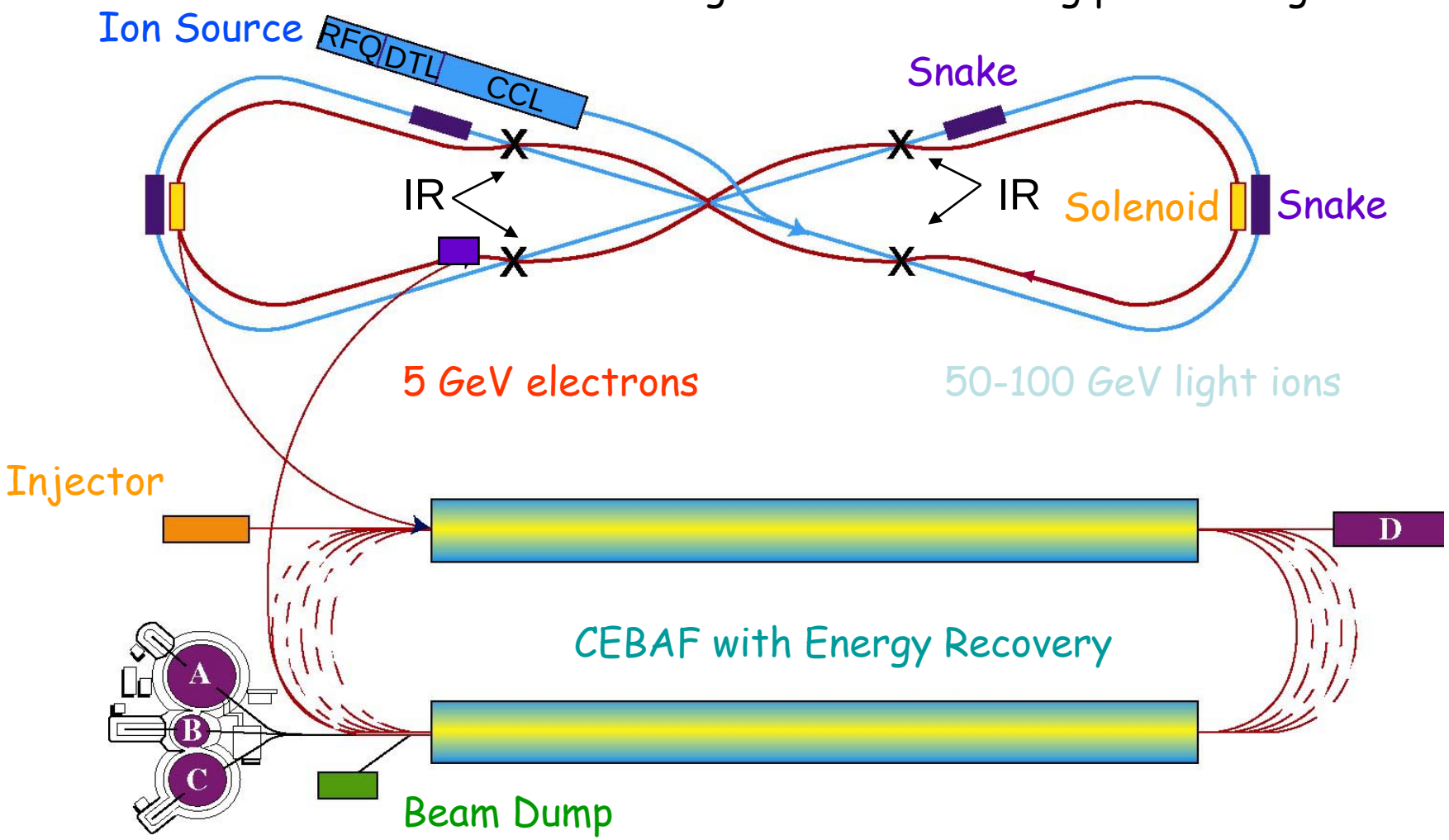


Transverse instability in Los Alamos PSR, bunched beam (1986)

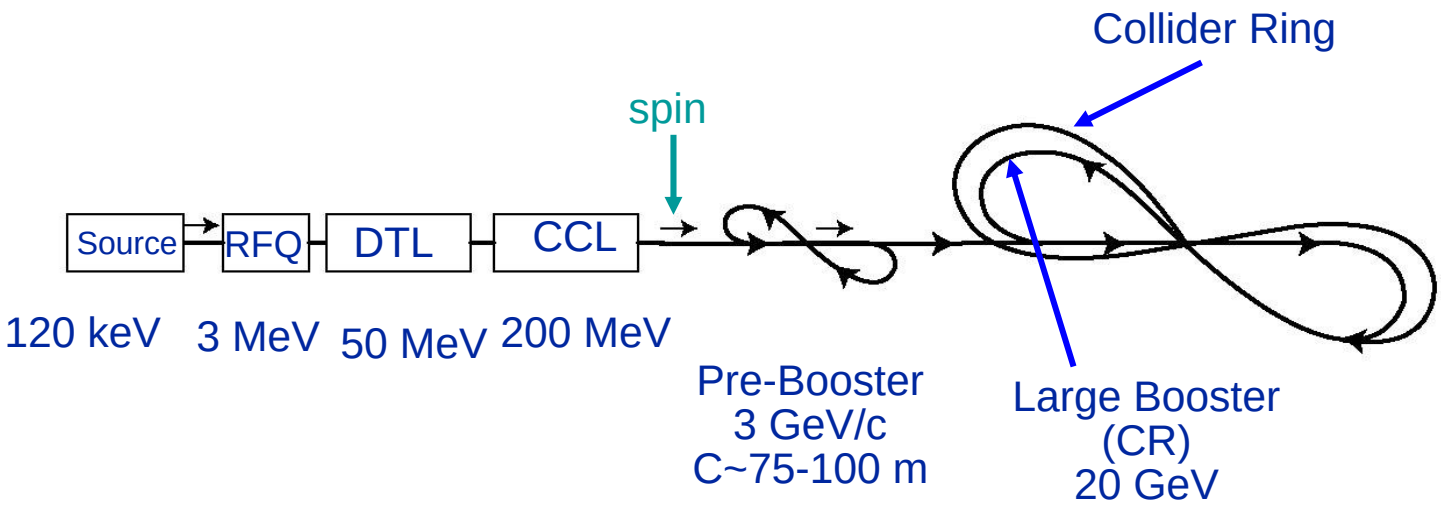


ELIC Layout

One accelerating & one decelerating pass through CEBAF



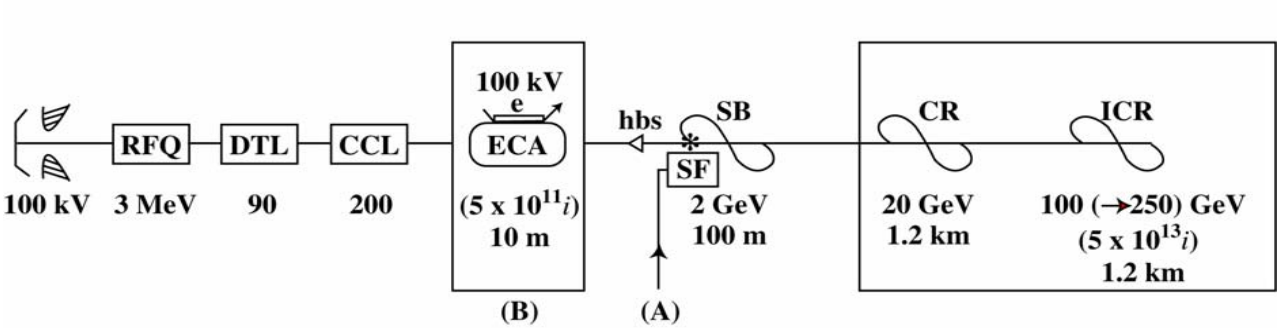
Ion Complex


Collider Ring
spin
Source
RFQ
DTL
CCL
120 keV
3 MeV
50 MeV
200 MeV
Pre-Booster
3 GeV/c
C~75-100 m
Large Booster
(CR)
20 GeV

ELIC Parameter Table

Parameter	Units	Point Design 1		Point Design 2		Point Design 3	
		e^-	Protons	e^-	Protons	e^-	Protons
Energy	GeV	5	50	5	50	5	50/100
Cooling	-	-	Yes	-	Yes	-	Yes
CR			No		Yes		Yes
Lumi	cm^{-2} sec^{-1}	1×10^{33}		1×10^{34}		6×10^{34} / 1×10^{35}	
N_{bunch}	ppb	1×10^{10}	2.5×10^{10}	2×10^{10}	5×10^{9}	1×10^{10}	1×10^{10}
f_c	MHz	150		500		1500	
I_{ave}	A	0.24	0.6	1.6	0.4	2.5	2.5
σ^*	μm	14	14	6	6	4.5/3.2	4.5/3.2
ε_n	μm	10	0.2	10	0.2	10	0.1
β^*	cm	20	5	4	1	2/1	1
σ_z	cm	0.1	5	0.1	1	0.1	1
ξ_e / ξ_i	-	0.5	0.006	0.1	0.01	0.2	0.01
$\Delta\nu_L$	-	-	0.05	-	0.05	-	0.09

ELIC Ion Complex

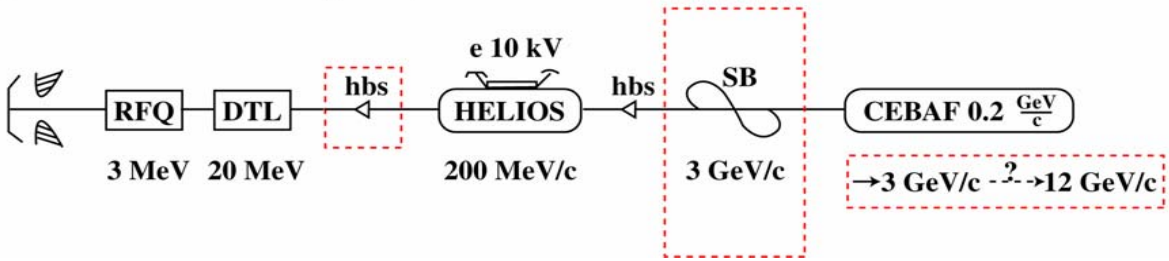


Option B: ● Positive source (p, d, He^3), = 20 m A
● Electron cooling accumulator (ECA)

hbs: Hollow beam stretcher

Option B: ● Negative source (H^-, D^-), ? = 10 m A
● Stripping foil (SF) in SB (small booster)

Ion Test Facility



200 MeV Accumulator Ring (20 MeV